Experiment No: 01

Experiment Name: To write a MATLAB program to evaluate performance of a 1/2-rated convolutionally encoded DS CDMA system in AWGN Channel.

Objective:

- To simulate a Direct sequence Code Division Multiple Access (DS-CDMA) communication system using MATLAB
- To implement a 1/2-rated convolutional encoder for forward error correction.
- To model transmission over an additive white Gaussian Noise (AWGN) channel.

Theory:

A Direct sequence Code Division Multiple Access (DS-CDMA) system spreads each user's data using a unique high-rate pseudo-random noise (PN) sequence, enabling multiple users to share the same frequency band with minimal interference. The spreading increases bandwidth but enhances resistance to jamming, interference, and multipath fading.

Convolutional coding is used for error correction by adding controlled redundancy to the data. A 1/2-rated convolutional encoder outputs two bits for every input bit, improving error detection and correction capabilities at the cost of increased bandwidth.

The AWGN (Additive White Gaussian Noise) channel is a fundamental noise model representing thermal noise in communication system. It degrades the transmitted signal, and the system's performance is typically assessed using Bit error rate (BER) against varying signal to noise Ratio (SNR)

In this experiment, the simulation involves

- Encoding random binary data using a 1/2-rated convolutional encoder
- Spreading the encoded data using a PN sequence
- Transmitting the spread signal over an AWGN channel
- Despreading and decoding the signal using a Viterbi decoder.
- Measuring the BER for different SNR values to asses performance.

Experiment No: 02

Experiment Name: To write a MATLAB program to evaluate performance of a 1/2-rated convolutionally encoded DS CDMA in AWGN and Rayleigh fading channel.

Objectives:

- To simulate a 1/2-rated convolutionally encoded DS-CDMA communication system using MATLAB
- To evaluate and compare the BER performance of the system under AWGN and Rayleigh fading channel conditions.
- To analyze the effectiveness of convolutional coding in improving system performance in both noise-dominated and multipath fading environments.

Theory:

DS-CDMA (Direct sequence Code Division Multiple Access) is a spread spectrum multiple access technique where each user's data is multiplied by a high-rate pseudo-random noise (PN) sequence. This process spreads the signal over a wider bandwidth, providing multiple access capability and robustness against interference and jaming.

To improve reliability, convolutional coding is used before spreading. A 1/2-rated convolutional encoder generates two output bits for every single input bit, introducing redundancy that enables the receiver to correct errors using algorithms, such as the viterbi decoder. This coding enhances performance in noisy and fading environments.

The communication channel plays a crucial rule in system performance. Two important models are considered:

<u>AWGN channel</u>: Represent a basic communication scenario where the only important is white Gaussian noise. It is commonly used in benchmarking system performance.

<u>Rayleigh Fading Channel</u>: Models a more realistic wireless environment where the signal experiences multipath propagation, causing rapid fluctuations in amplitude and phase. This is the typical in mobile and urban setting with no direct line-of-sight between transmitter and receiver.

In this experiment, random binary data is encoded using a 1/2-rated convolutional encoder. The spread signal is transmitted over either AWGN or Rayleigh fading channel.

Experiment No: 03

Experiment Name: To write a MATLAB program to evaluate performance of a 1/2-rated convolutionally encoded DS CDMA system in AWGN and Rician fading channel.

Objectives:

- To implement a DS-CDMA system with 1/2-rated convolutional encoding in MATLAB
- To simulate and evalute the BER performance of the system under AWGN and Rician fading channels.
- To analyze the impact of convolutional coding on system reliability in both Gaussian noise and line-of-sight multipath fading environments.

Theory:

DS-CDMA (Direct Sequence Code Division Multiple Access) is a spread spectrum technique where the input data is multiplied by a high rate pseudo-random noise (PN) sequence. This process spreads the signal over a broader bandwidth, allowing multiple user to transmit simultaneously and proving inherent resistance to interference and narrowband jaming.

To enhance error resilience, convolutional coding is applied before spreading. A 1/2-rated convolutional encoder outputs two bits for each unit input bit, introducing redundancy that allows error correction through decoding techniques like the viterbi algorithm. This improves performance, especially in noisy or fading conditions.

Two types of channel impairments are considered:

AWGN Channel: The basic noise model introduces Gaussian-distributed random noise to the transmitted signal, simulating thermal noise in ideal communication conditions.

Rician Fading Channel: Represents a realistic wireless communication scenario where, in addition to multiple reflected paths (multipath), there is a strong direct line of sight (LOS) component. Rician fading is characterized by the K-factor, which indicates the ratio of the power in the direct path to the power in the scattered paths. It is more favorable than Rayleigh fading due to the presence of the LOS component but still introduces significant signal distortion.

In this experiment,
random binary data is generated and convolutionally encoded with a 1/2 rate and the signal is transmitted through both AWGN and Rician fading channels.

Experiment No: 04

Experiment Name: To write a MATLAB program to study the performance of a differentially encoded OQPSK based wireless communication system.

Objectives:

- To simulate a wireless communication system using Differentially Encoded Offset Quadrature Phase Shift Keying (OQPSK) in MATLAB
- To analyze the Bit Error Rate (BER) performance of the system over an AWGN channel
- To observe the impact of differential encoding and OQPSK modulation on system robustness and spectral efficiency.

Theory:

Offset Quadrature Phase Shift Keying (OQPSK) is a variant of Quadrature Phase Shift Keying (QPSK) in which the timing of the in-phase (I) and quadrature (Q) components is offset by half a symbol period. This delay ensures that both I and Q components do not change simultaneously, reducing the likelihood of large phase shifts and thus lowering amplitude fluctuations. As a result, OQPSK is more power-efficient and better suited for non-linear amplification, making it ideal for wireless communication system.

Differential encoding is used to eliminate the need for absolute phase reference at the receiver. Instead of transmitting the absolute symbol phase, the system transmits the change in phase between successive symbols. This approach simplifies receiver design and makes the system more robust to phase ambiguities introduced by the channel or receiver hardware.

This experiment typically involve:

- Generating a binary data stream
- Applying differential encoding to the data
- Modulating the encoded data using OQPSK
- Transmitting the modulated signal over an AWGN channel.
- Demodulating and differentially decoding the receiver signal.
- Measuring Bit Error Rate (BER) over a range of Signal-to-Noise Ratios (SNRs) to evaluate system performance.

This experiment highlights the advantages of using OQPSK with differential encoding.

Experiment No: 05

Experiment Name: To develop a MATLAB source to simulate an Interleaved FEC encoded wireless communication system with implementation of BPSK digital modulation technique. Need to show at least three waveforms generated at different sections of the simulated system.

Objectives:

- To simulate a wireless communication system that using forward Error Correction (FEC) encoding with interleaving and BPSK modulation in MATLAB
- To analyze the Bit Error rate (BER) performance of the system over an AWGN channel with and without interleaving.
- To observe and interpret three key waveforms encoded bitstream, modulated BPSK signal, and received signal after transmission through a noisy channel.

Theory:

Forward Error Correction (FEC) is a digital signal processing technique used to detect and correct errors at the receiver without requiring retransmission. It adds redundancy to the transmitted data using encoding algorithms such as convolutional or block codes. Common FEC codes including Hamming code, BCH, Reed-solomon and convolutional codes.

Interleaving is the used in conjunction with FEC to combat burst errors - errors that occur in clusters due to channel fading or noise. Interleaving rearranges the order ~~to~~ of encoded bits before transmission so that consecutive errors at the receiver are spread out when deinterleaved, allowing the FEC decoder to correct them more effectively.

Binary Phase Shift Keying (BPSK) is a simple and robust digital modulation tecqnique where binary 0 and 1 are represented by two phases of a carrier signal (typically 0° and 180°). BPSK offers high noise immunity and is used widely in low-bandwidth wireless system.

Here, for this experiment, waveform plots can be generated at three key points:

- The FEC encoded and interleave bitstream
- The BPSK modulated waveform
- The received noisy signal at the demodulator input.

Experiment No: 06

Experiment Name: To develop a MATLAB source to simulate an Interleaved FEC encoded wireless communication system with implementation of QPSK digital modulation technique. Need to show at least three waveforms generated at different sections of the simulated system.

Objectives:

- To simulates a wireless communication system incorporating FEC encoding with interleaving and QPSK modulation in MATLAB.
- To evaluate the system's BER performance over an AWGN channel with and without interleaving.
- To visualize three important waveforms from different stages: interleave bitstream, QPSK modulated signal, and received signal after AWGN channel.

Theory:

Forward Error Correction (FEC) is a critical technique used in digital communication to improve reliability by encoding redundant bits into the transmitted data. Common FEC schemes includes Hamming, convolutional, Reed-Solomon codes. These allow the receiver to detect and correct errors introduced by noise without needing retransmission.

However, many channels wireless channels introduce burst errors (several bits ~~ar~~ in error in a sequence due to fading or interface. Interleaving is used before modulation to shuffle the order of the bits so that burst errors are spread out ~~an~~ over multiple codewords after demodulation. This increases the effectiveness of FEC decoding.

Quadrature Phase Shift Keying (QPSK) is a widely-used digital modulation scheme that maps ~~to~~ two bits per symbol using four distinct phases (0°, 90°, 180°, 270°). It is bandwidth-efficient and robust to noise, making it ideal for modern communication system.

Waveform to be be shown:

- Interleaved bitstream
- QPSK modulated signal
- Received noisy signal after transmission through AWGN channel.

Experiment No: 07

Experiment Name: To develop a MATLAB source to simulate an Interleaved FEC encoded wireless communication system with implementation of 4-QAM digital modulation technique. Need to show at least three waveforms generated at different section of the simulated system.

Objectives:

- To simulate a wireless communication system using FEC encoding with interleaving and 4-QAM modulation in MATLAB
- To evaluate the system's BER performance over an AWGN channel.
- To visualize waveforms at different stages of the communication system.

Theory:

Forward Error Correction (FEC) adds redundancy to transmit data, enabling the receiver to correct errors without retransmission. Common FEC codes including Hamming and convolutional codes.

Interleaving rearranges encoded bits to spread burst errors across multiple codewords, improving FEC decoding effectiveness, especially in noisy or fading channels.

4-QAM (Quadrature Amplitude Modulation) is a modulation scheme where two bits are mapped to one of four distinct constellation points in the I-Q plane. It is ~~typically~~ spectrally efficient and widely used in digital communication system.

In this system:

- Data ~~ha~~ is encoded using FEC, then interleaved
- Interleaved bits are modulated using 4-QAM
- The signal is transmitted through an AWGN channel, then demodulated, deinterleaved, and decoded.
- BER is measured and waveforms are plotted at
  1. Interleaved bitstream
  2. 4-QAM modulated signal
  3. Noisy received signal.

Experiment No: 08

Experiment Name: To develop a MATLAB source to simulate an Interleaved FEC encoded wireless communication system with the implementation of 16-QAM digital modulation technique. Need to show at least three waveforms generated at different sections of the simulated system.

Objectives:

- To implement FEC encoding with interleaving in a wireless communication system.
- To simulate 16 QAM modulation and evaluate system performance over an AWGN channel.
- To visualize key signal waveforms at different stage of the system.

Theory:

FEC (Forward Error correction) adds redundancy to transmitted data to detect and correct errors at the receiver, improving reliability with retransmission. Common FEC codes including Hamming and convolutional codes.

Interleaving rearranges encoded bits before transmission to combat burst errors, making FEC more effective, especially in noisy and fading channels.

16-QAM (Quadrature Amplitude Modulation) maps 4 bits per symbol to one of 16 distinct constellation points, offering high spectral efficiency.

In this system:

- Data is encoded using FEC, interleaved, and modulated using 16-QAM
- The signal is passed through an AWGN channel
- Demodulation, deinterleaving, and decoding are applied to recover the original data.
- Key waveforms visualized:
    1. Interleaved bitstream
    2. 16-QAM modulated signal
    3. Received noisy signal.